EUV mask pattern inspection using EB projection optics

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Introduction

Detecting the defects of smaller than 18 nm in size is required for the hp 16 nm EUV mask in ITRS 2010 update. In order to achieve the inspection sensitivity and applicability for hp 16 nm, we utilized an inspection system with projection EB optics. The projection inspection system has potential to take clear images of small patterns than that by DUV and to inspect masks with higher throughput than that of SEM inspection system.

We demonstrated the basic performance of imaging quality and inspection sensitivity. The detectability of thin absorber defect was also discussed.

Our goal

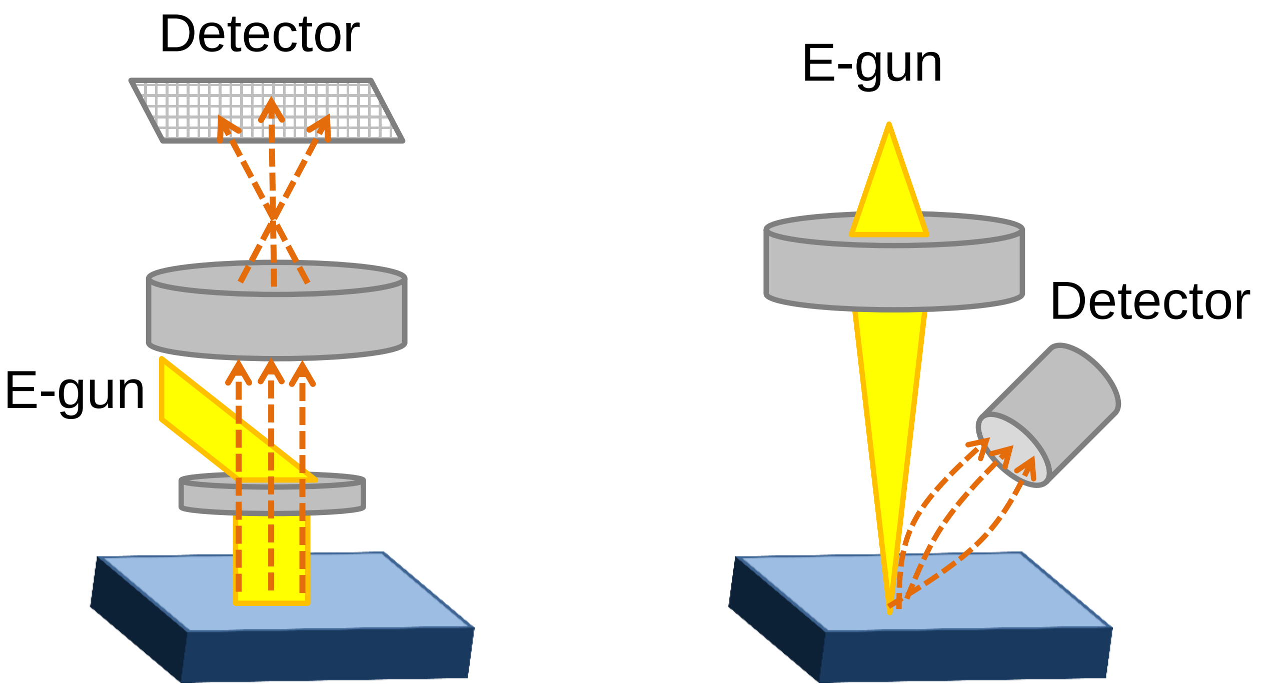
EUVL mask requirements (ITRS roadmap 2010 update)

Year of Production	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
DRAM 1/2 pitch (nm) (contacted)	40	36	32	28	25	23	20	18	16	14
Flash 1/2 pitch (nm) (un-contacted poly)	28	25	23	20	18	16	14	13	11	10
MPU/ ASIC Metal 1 (M1) 1/2 pitch (nm) (contacted)	38	32	27	24	21	19	17	15	13	12
Mask minimum primary feature size (nm)	99	88	78	70	62	55	49	44	39	35
Defect size (nm)	**32**	**29**	**25**	**23**	**20**	**18**	**16**	**14**	**13**	**11**

Our target is

- defect detection of 18 nm in size.
- 13 hours of inspection throughput.

Inspection with PEM(Projection Electron Microscope) technique



	PEM	SEM
Optics	Wide irradiation	Point irradiation
Detector	Area sensor	Point detector

History of inspection system using PEM technique

EBARA

History of MODEL EBEYE ("Model EBEYE" is EBARA's model code)

'00 | '01 | '02 | '03 | '04 | '05 | '06 | '07 | '08 | '09 | '10 | '11

- '00: Project start at EBARA
- '03: alpha_tool
- '04: EBeye300 (for Wafer)
  - Pattern inspection
  - VC inspection
- '09: EBeyeM (for Mask)
  - Pattern inspection
  - 2x-nm upgrade

alpha_tool
- 200 mm Wafer
- D/R= 600 MPPS

D/R (Data Rate)

EBeye300
- 200/ 300 mm Wafer
- D/R= 600 MPPS

EBeyeM
- EUV Mask
- D/R= 600 MPPS

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Experimental conditions

Experimental PEM system for 1x-nm EUV mask pattern inspection

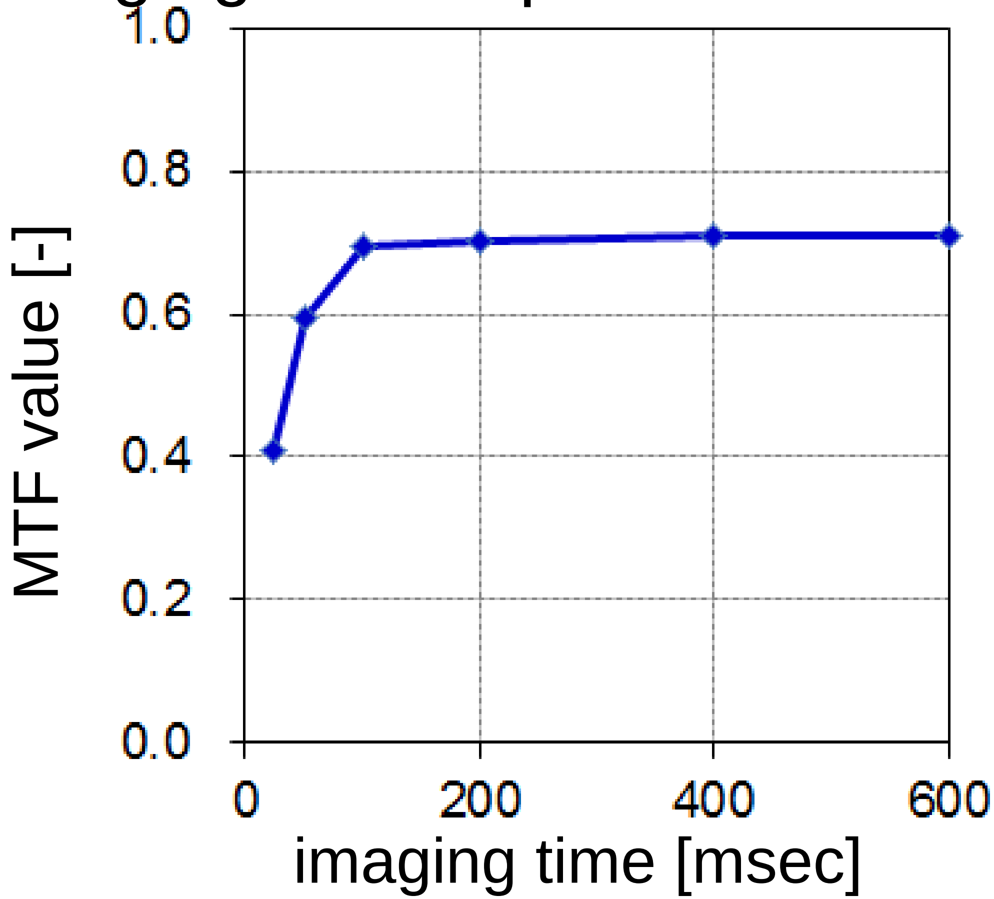
E-gun:	LaB_6
Detector:	CCD
Pixel size:	20 nm
Irradiation area:	100x50 um
Landing energy:	0-3000 eV

EUV mask structure and pattern

Mask structure:	LR-TaBN(51 nm), CrN(10 nm), Si-cap.(11 nm), ML(40 pairs)
Mask pattern:	hp 80 - 400 nm(for image quality test) hp108, 128 nm (for defect inspection test)

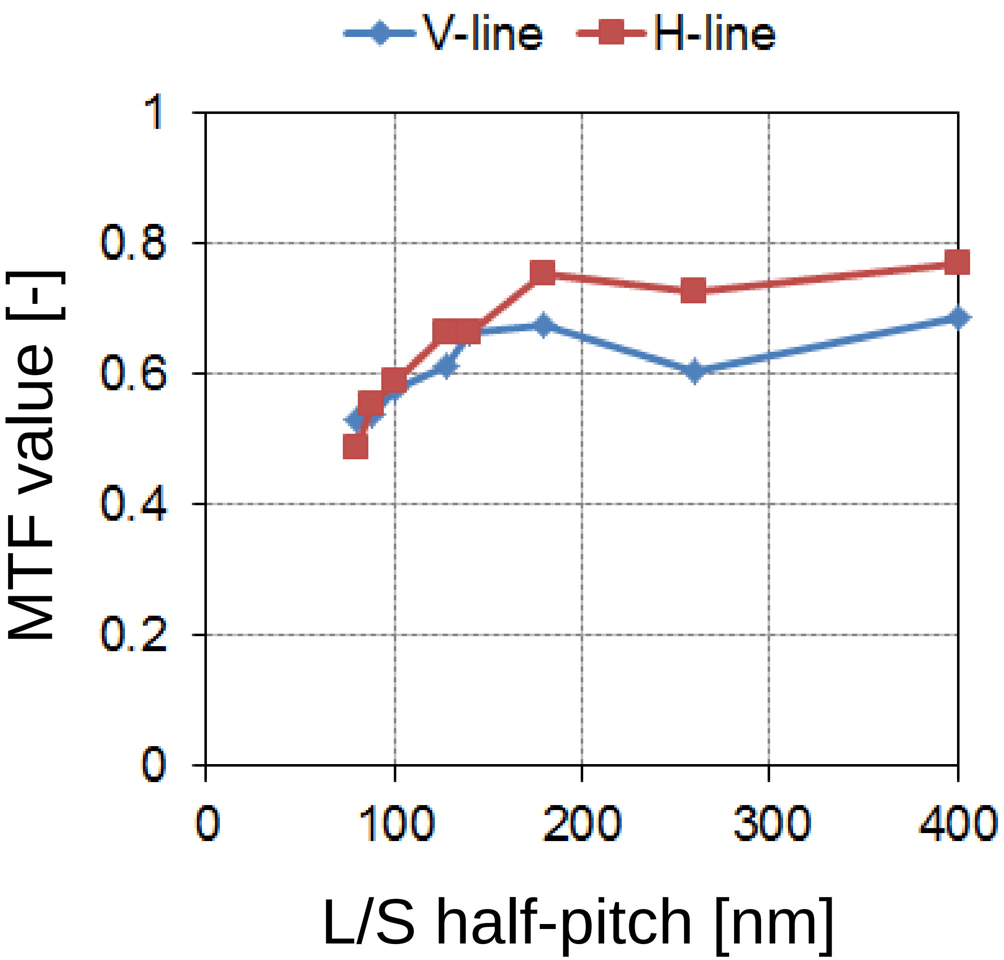
Image quality hp 128 nm L/S

- Imaging time dependent MTF curve -

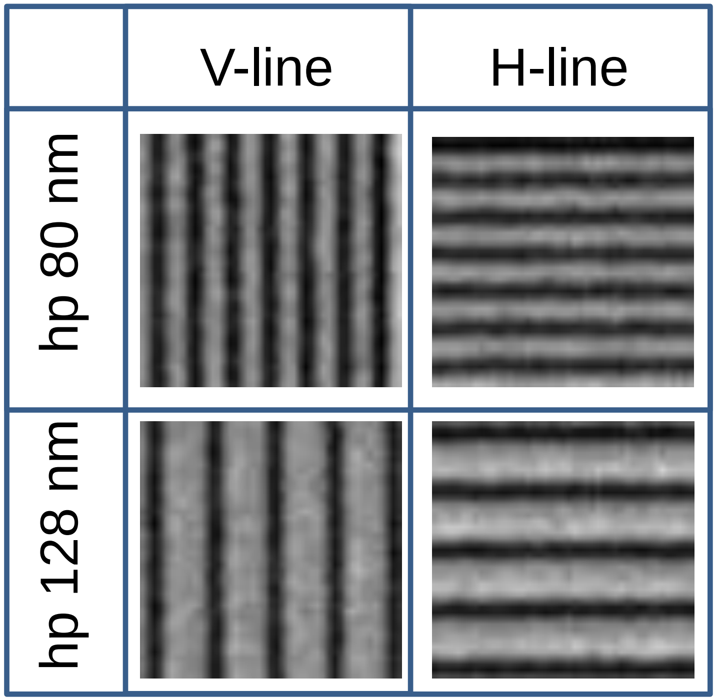


50%-MTF is one of the reference indexes of image quality.
We obtain 60%-MTF at 50 msec imaging time but the MTF value quickly fell below 50 msec.

Image quality MTF value vs. L/S half-pitch



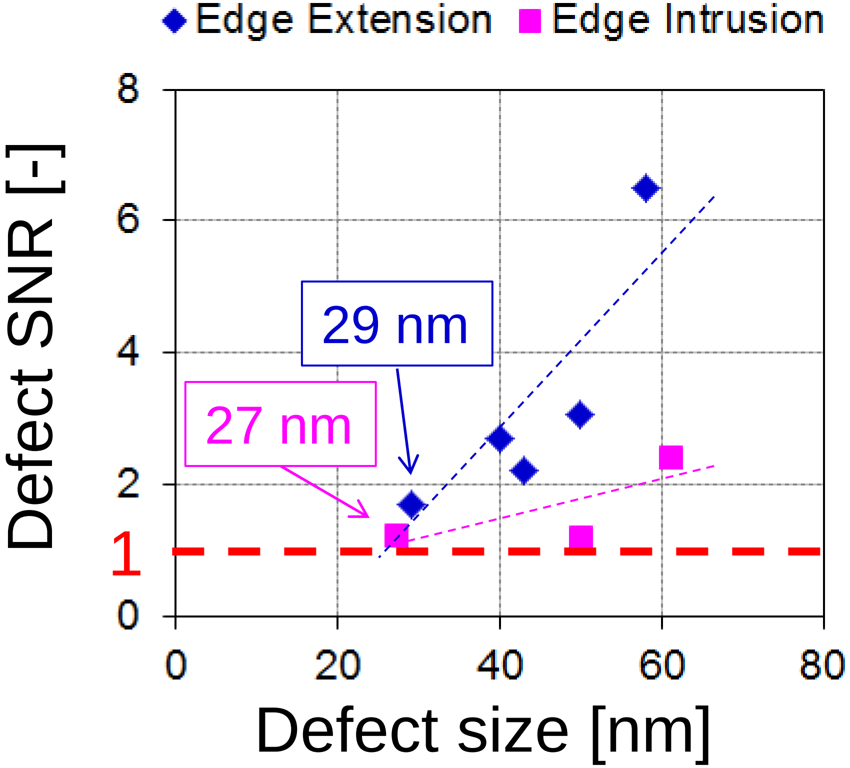
PEM images



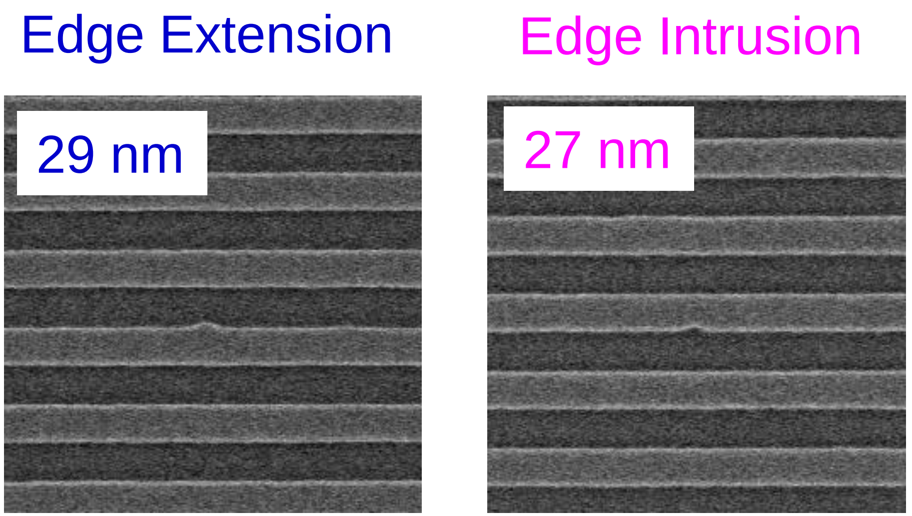
50%-MTF was achieved from hp 80 to 400 nm CD range.

Defect signal-noise ratio

hp 128 nm



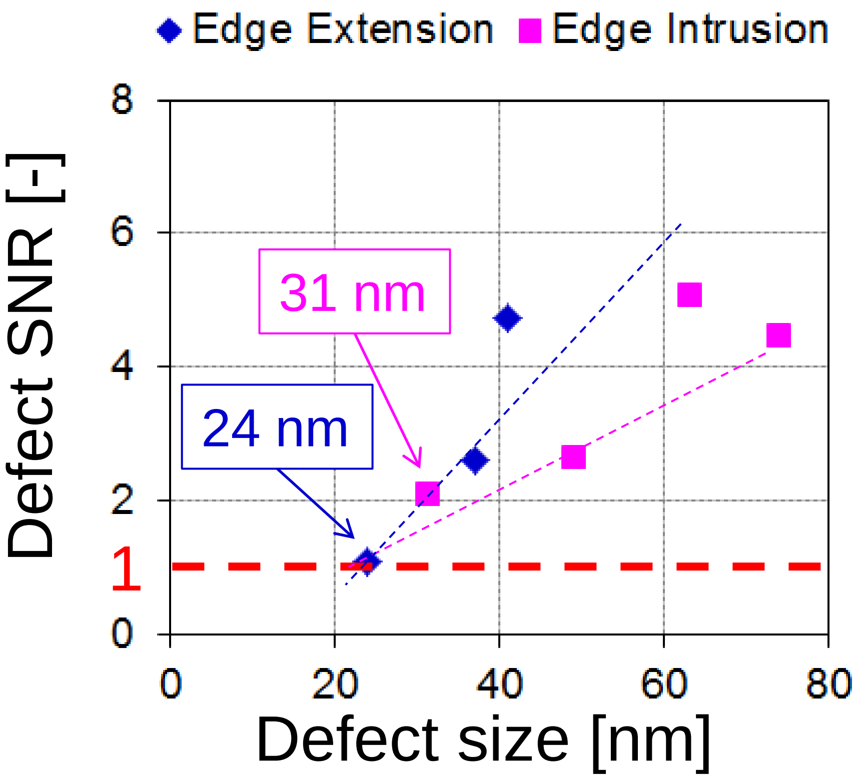
SEM images of identified PDs

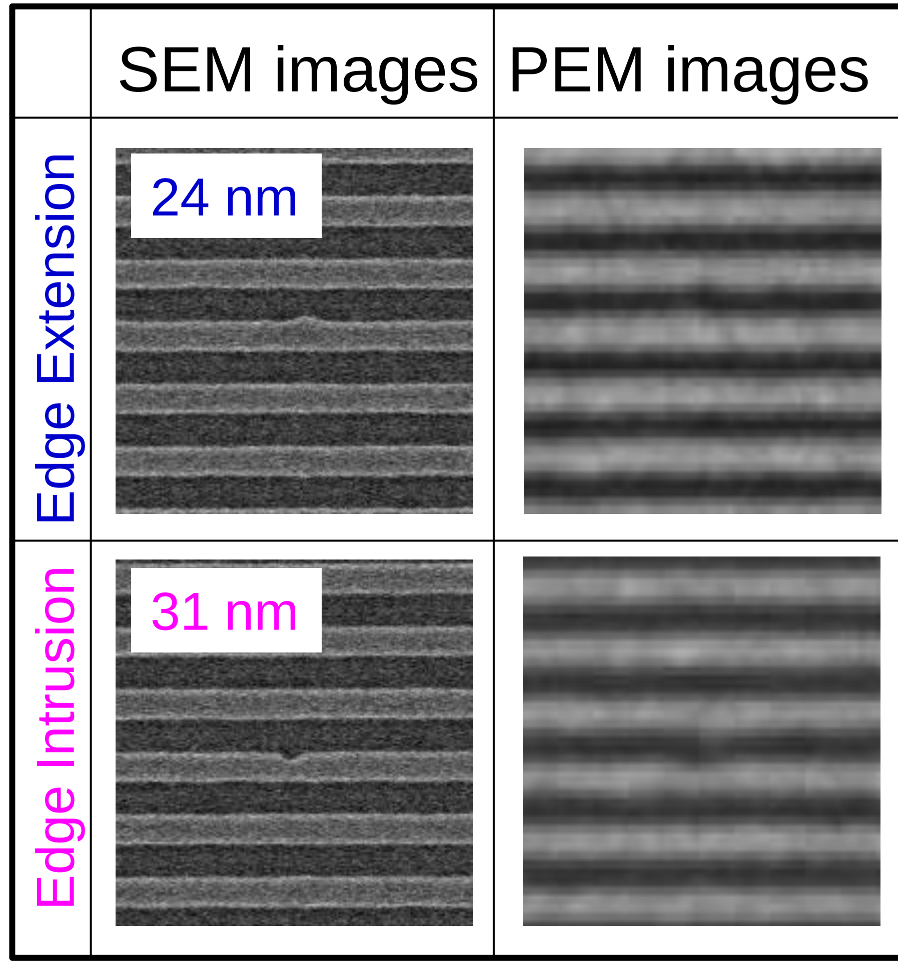


Defect SNR=1 means detection limit.
The noise reduction is one of the major challenges to achieve detection defects of < 20 nm in size.

Defect signal-noise ratio

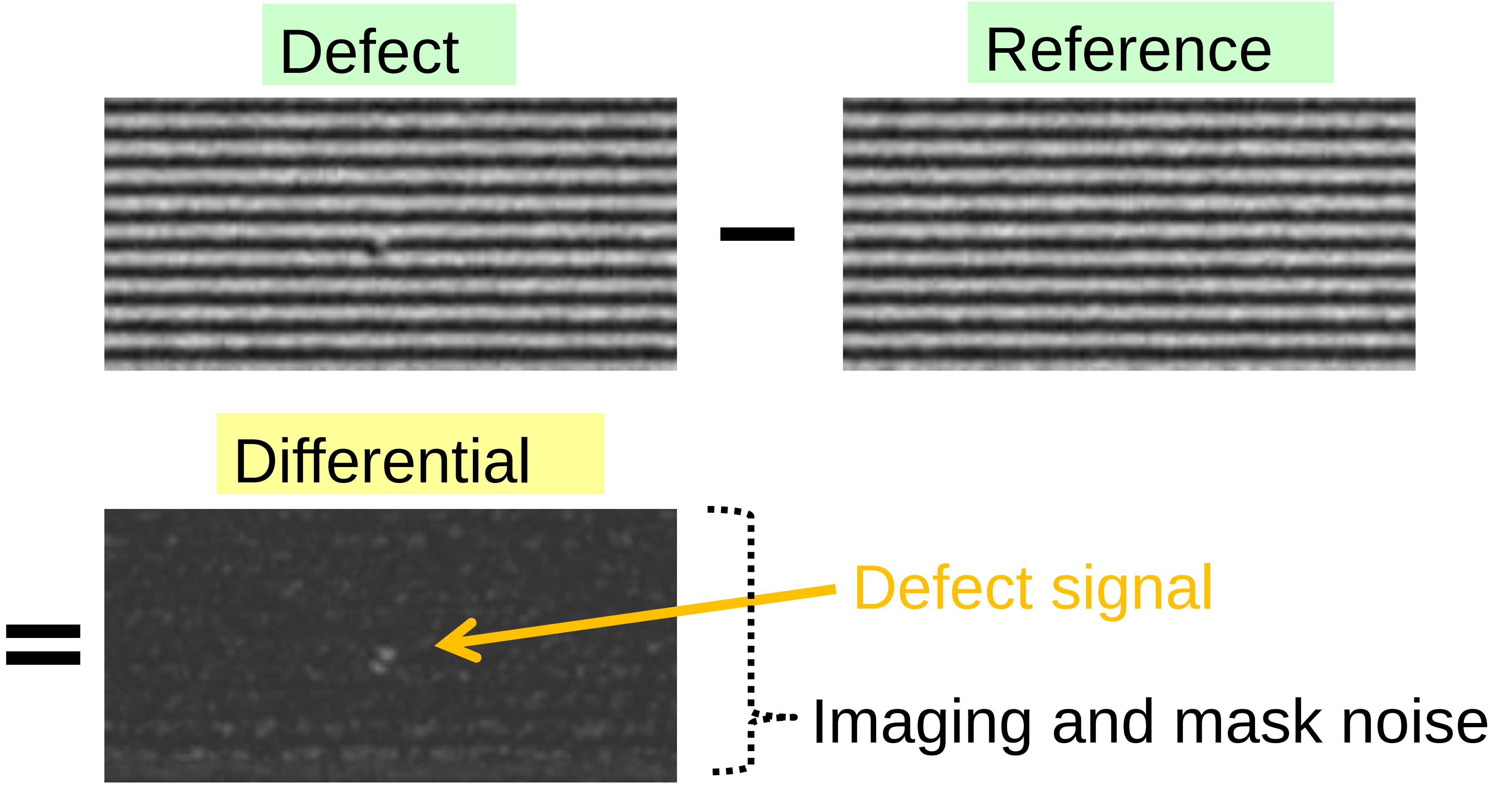
hp 88 nm





The 24 nm size of edge extension defect was successfully identified.

Example of defect detection signal



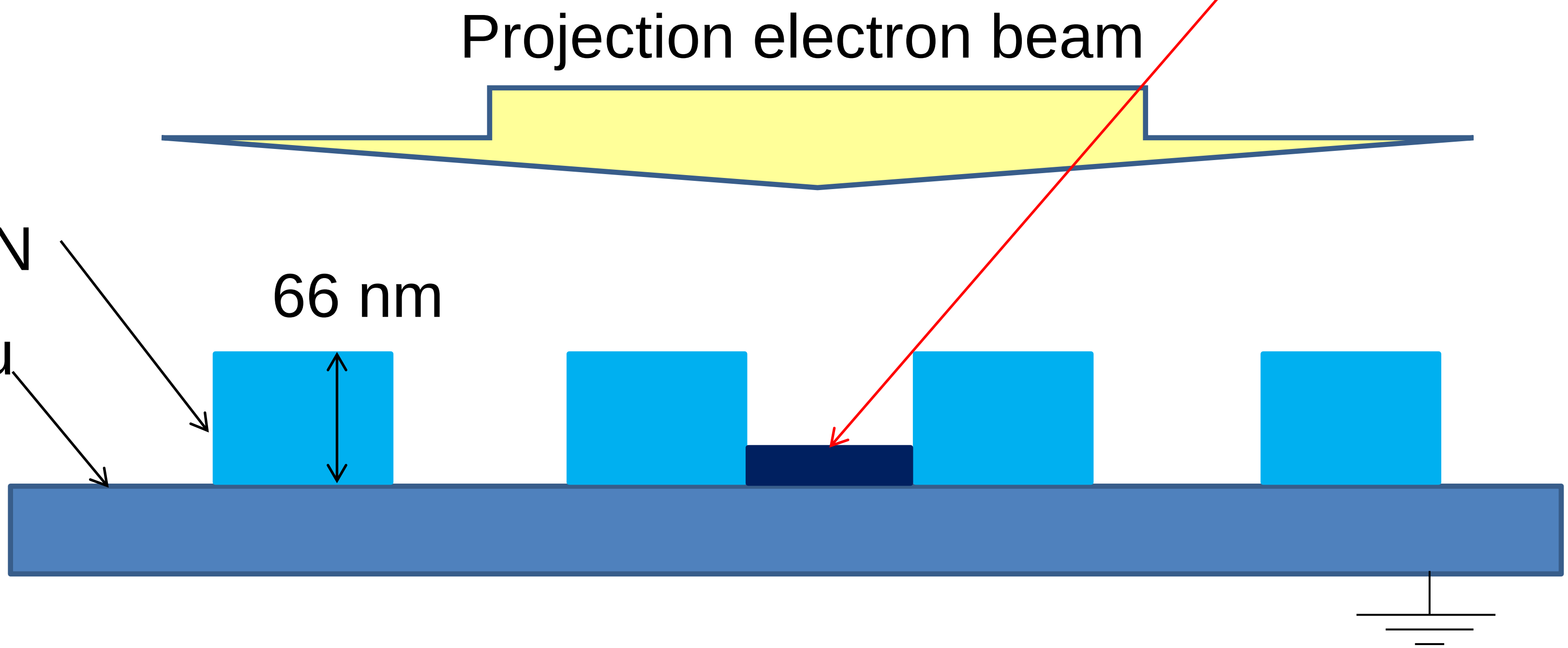
Noise sets a limitation of the inspection sensitivity.

Capability of thin absorber defect detection

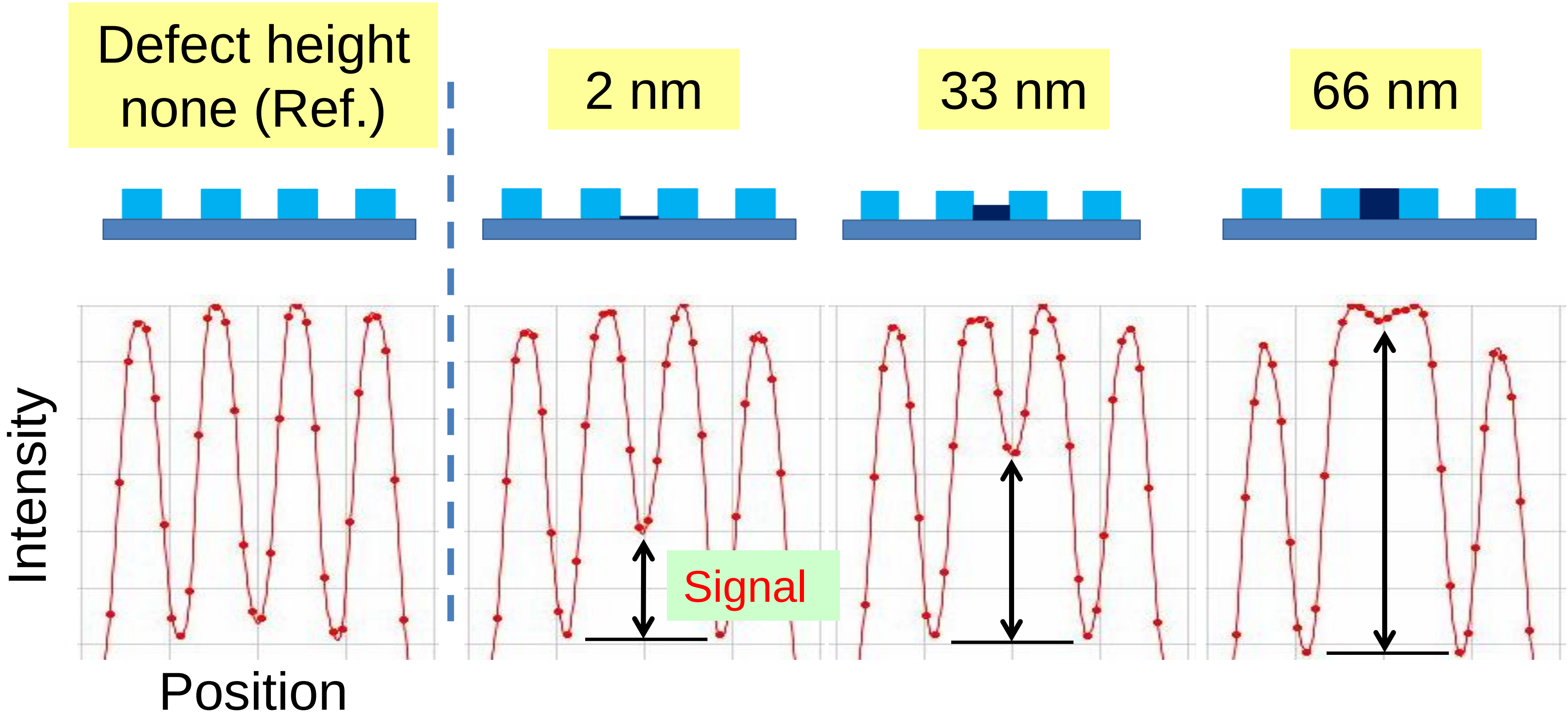
Simulation Condition

Beam:	Projection beam
Pattern:	66 nm height hp 88 nm L/S
Defect:	Thin absorber defect
Charging:	no

Thin absorber defect
Defect (TaN) height is varying with
66 nm (full height), 33 nm, 2 nm, 0 nm



Simulation result



PEM system has a capability to catch the 2 nm thick of thin absorber defect.

Summary

The basic performance of the PEM technique was evaluated using experimental PEM system.

Clear images of hp 80 nm L/S with 50%-MTF were obtained under the condition of 50 msec imaging time.

Defect of 24 nm size in hp 88 nm L/S was successfully identified.

EB simulation result suggests that the PEM system has a capability to catch the thin absorber defects.

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